

WHAT IS CLAIMED IS:

1. A multi-polar electrostatic chuck for clamping a substrate and controlling a heat transfer associated therewith, the electrostatic chuck  
5 comprising:
  - a clamping plate, the clamping plate further comprising:
    - a semiconductor platform;
    - a first electrically conductive layer formed over a top surface of the semiconductor platform, wherein the first electrically conductive layer  
10 comprises a plurality of portions, wherein the plurality of portions are generally electrically isolated from one another, therein defining a plurality of poles associated with the electrostatic chuck; and
    - a plurality of electrically insulative protrusions formed over the first electrically conductive layer, the plurality of protrusions extending a first  
15 distance from a top surface of the first electrically conductive layer, wherein the plurality of protrusions are operable to generally contact the substrate, therein defining a protrusion contact area, and wherein the plurality of protrusions generally define a plurality of gaps therebetween having a second distance associated therewith;
  - 20 a base plate operable to transfer thermal energy from the substrate through the clamping plate; and
  - a plurality of electrodes electrically connected to the respective plurality of portions of the first electrically conductive layer, wherein the plurality of electrodes are further operable to be connected to a voltage source.
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2. The electrostatic chuck of claim 1, wherein the clamping plate further comprises a second electrically conductive layer, the second electrically

conductive layer comprising a plurality of vertical interconnects and a plurality of portions formed over a bottom surface of the semiconductor platform, wherein the plurality of portions of the second electrically conductive layer are generally electrically isolated from one another, wherein the second electrically conductive layer is electrically connected to the first electrically conductive layer through the plurality of vertical interconnects, and wherein the plurality of electrodes are electrically connected to the respective plurality of portions of the second electrically conductive layer.

3. The electrostatic chuck of claim 2, wherein the plurality of vertical interconnects comprise a plurality of vias generally extending through the semiconductor platform from the top surface of the semiconductor platform to the bottom surface of the semiconductor platform.

4. The electrostatic chuck of claim 2, wherein the plurality of vertical interconnects are generally formed on a sidewall of the semiconductor platform, wherein the plurality of vertical interconnects are electrically connected to the respective plurality of electrodes.

5. The electrostatic chuck of claim 4, wherein the plurality of electrodes comprises a respective plurality of spring-forced sidewall contact electrodes, wherein the plurality of spring-forced sidewall contact electrodes are operable to electrically contact the respective plurality of vertical interconnects.

6. The electrostatic chuck of claim 2, wherein the base plate comprises a first electrically insulative layer and a third electrically conductive layer formed thereon, wherein the first electrically insulative layer resides

between the base plate and the third electrically conductive layer, and wherein the third electrically conductive layer further comprises a plurality of portions electrically isolated from one another, wherein the plurality of portions of the third electrically conductive layer are electrically connected to the respective plurality  
5 of portions of the second electrically conductive layer.

7. The electrostatic chuck of claim 6, wherein the third electrically conductive layer generally resides along a sidewall and a top surface of the base plate, and wherein the plurality of electrodes are electrically connected to the  
10 respective plurality of portions of the third electrically conductive layer at the sidewall of the base plate.

8. The electrostatic chuck of claim 6, wherein the base plate is comprised of amorphous silicon, aluminum, or copper.  
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9. The electrostatic chuck of claim 6, wherein the third electrically conductive layer comprises one or more of tungsten silicide, tungsten, or titanium.

20 10. The electrostatic chuck of claim 6, wherein the first electrically insulative layer is comprised of silicon dioxide.

11. The electrostatic chuck of claim 2, wherein the base plate is generally electrically conductive and comprises a plurality of segments  
25 electrically isolated from one another, wherein the plurality of portions of the second electrically conductive layer are electrically connected to the respective plurality of segments of the base plate, and wherein the plurality of electrodes are

electrically connected to the respective plurality of segments of the base plate.

12. The electrostatic chuck of claim 11, wherein the base plate is comprised of aluminum, copper, a metal alloy, or amorphous silicon.

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13. The electrostatic chuck of claim 2, wherein the second electrically conductive layer comprises one or more of tungsten silicide, tungsten, or titanium.

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14. The electrostatic chuck of claim 1, wherein the first electrically conductive layer further comprises a plurality of sidewall interconnects generally formed on a sidewall of the semiconductor platform, wherein the plurality of electrodes are electrically connected to the respective plurality of sidewall interconnects.

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15. The electrostatic chuck of claim 14, wherein the plurality of electrodes comprises a respective plurality of spring-forced sidewall contact electrodes, wherein the plurality of spring-forced sidewall contact electrodes are operable to electrically contact the respective plurality of sidewall interconnects.

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16. The electrostatic chuck of claim 1, wherein base plate further comprises one or more fluid conduits, wherein a cooling fluid is operable to flow through fluid conduits, therein substantially cooling the plurality of base plate.

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17. The electrostatic chuck of claim 1, wherein the base plate is vacuum brazed to the clamping plate.

18. The electrostatic chuck of claim 1, wherein the first electrically conductive layer comprises one or more of tungsten silicide, tungsten, or titanium.

5           19. The electrostatic chuck of claim 1, wherein the base plate is comprised of an electrically conductive material, and wherein the clamping plate is electrically insulated from the base plate.

20.       20. The electrostatic chuck of claim 19, wherein the base plate is  
10 comprised of aluminum, copper, a metal alloy, or amorphous silicon.

21.       21. The electrostatic chuck of claim 19, further comprising an intermediate plate, wherein the intermediate plate electrically insulates the clamping plate from the base plate.

15           22. The electrostatic chuck of claim 21, wherein the intermediate plate comprises an aluminum nitride insulator wafer which is metallized on a top and a bottom surface thereof.

20           23. The electrostatic chuck of claim 21, wherein the clamping plate is vacuum-brazed to the intermediate plate and the intermediate plate is vacuum-brazed to the base plate.

24.       24. The electrostatic chuck of claim 1, wherein the semiconductor  
25 platform is comprised of silicon.

25.       25. The electrostatic chuck of claim 1, wherein the plurality of

protrusions are generally comprised of silicon dioxide.

26. The electrostatic chuck of claim 1, wherein the plurality of portions of the first electrically conductive layer are generally electrically isolated from one another by silicon dioxide.

27. The electrostatic chuck of claim 1, wherein the plurality of portions of the first electrically conductive layer are generally electrically isolated from one another by an electrically insulative insert.

28. The electrostatic chuck of claim 1, wherein each of the plurality of protrusions comprises a protection layer formed thereover.

29. The electrostatic chuck of claim 28, wherein the protection layer is comprised of silicon nitride.

30. The electrostatic chuck of claim 1, wherein the plurality of protrusions comprise an array of micro-electromechanical structures.

31. The electrostatic chuck of claim 30, wherein each of the plurality of micro-electromechanical structures has a surface roughness of approximately 0.1 microns or less.

32. The electrostatic chuck of claim 1, further comprising a voltage control system operable to control a voltage to the plurality of electrodes from the voltage source, wherein the voltage is operable to induce an electrostatic force between the clamping plate and the substrate, therein selectively clamping the

substrate to the clamping plate.

33. The electrostatic chuck of claim 1, further comprising a pressure control system operable to control a backside pressure of a cooling gas residing  
5 within the plurality of gaps between a first pressure and a second pressure, wherein a heat transfer coefficient of the cooling gas is primarily a function of the backside pressure.

34. The electrostatic chuck of claim 33, wherein the first distance is  
10 less than or about equal to the mean free path of the cooling gas.

35. The electrostatic chuck of claim 33, wherein the first pressure and second pressure are selected such that a thermal conduction between the substrate and the clamping plate through the cooling gas is in a free molecular  
15 regime, wherein the heat transfer coefficient of the cooling gas is primarily a function of the backside pressure and is substantially independent of the first distance.

36. The electrostatic chuck of claim 33, wherein the clamping plate  
20 further comprises one or more gas distribution grooves associated with the top surface thereof, the one or more gas distribution grooves extending a third distance into the clamping plate, wherein the third distance is substantially larger than the first distance, and wherein each of the one or more gas distribution grooves intersects one or more of the plurality of gaps, such that a cooling gas  
25 flow in a viscous regime is operable to occur therethrough, thereby allowing a cooling of the substrate to be quickly initiated.

37. The electrostatic chuck of claim 36, further comprising a gas conduit fluidly coupled between the pressure control system and at least one of the one or more gas distribution grooves, wherein the gas conduit is operable to permit a range of backside pressures of the cooling gas within the plurality of gaps in response to the pressure control system.

38. The electrostatic chuck of claim 33, wherein one of the plurality of protrusions comprises a ring having a diameter, wherein the diameter of the ring is slightly smaller than a diameter of the substrate, and wherein the ring is generally concentric with the substrate and configured to generally provide a seal between the clamping plate and the substrate, therein defining an internal region of the clamping plate, wherein the cooling gas residing in the internal region of the clamping plate is generally isolated from an external environment.

39. The electrostatic chuck of claim 1, wherein a ratio of the protrusion contact area to a surface area of the substrate is about 0.1 or more.

40. The electrostatic chuck of claim 1, wherein the base plate is thermally coupled to the clamping plate.

41. The electrostatic chuck of claim 1, wherein the first distance is approximately 1 micron.

42. A method of clamping a substrate and controlling a heat transfer associated therewith, the method comprising:

placing the substrate on a surface having a plurality of protrusions extending therefrom, the plurality of protrusions defining a plurality of gaps



therebetween and a first distance between the substrate and the surface,  
wherein the first distance is associated with a mean free path of a cooling gas  
within the gaps;

applying a voltage between at least two regions of the surface, wherein an  
5 electrostatic force generally attracts the substrate to the surface; and

controlling a pressure of the cooling gas in the gaps, wherein a heat  
transfer coefficient of the cooling gas within the gaps is primarily a function of  
pressure and substantially independent of the gap distance.

10 43. The method of claim 42, wherein controlling the pressure  
comprises:

achieving a first pressure of the cooling gas within the gaps to achieve a  
first heat transfer coefficient; and

achieving a second pressure of the cooling gas that is greater than the  
15 first pressure within the gaps to achieve a second heat transfer coefficient that is  
greater than the first heat transfer coefficient.

44. The method of claim 43, wherein the first pressure is about 0 Torr  
and the first heat transfer coefficient is about 0, and wherein the second pressure  
20 is between about 100 Torr to about 250 Torr.

45. The method of claim 42, wherein the surface on which the  
substrate resides further comprises one or more gas distribution grooves, each of  
the one or more gas distribution grooves intersecting one or more of the plurality  
25 of gaps, the one or more gas distribution grooves being substantially larger than  
the gaps such that a cooling gas flow therethrough occurs in a viscous regime,  
thereby allowing a cooling of the substrate to be quickly initiated.

46. The method of claim 45, wherein controlling a pressure in the gaps comprises flowing the cooling gas through the gaps via the one or more gas distribution grooves.

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47. The method of claim 42, wherein the voltage is less than 300V.